

THAT WHICH IS CLAIMED IS:

1. A laminate for high strength, low weight gas enclosure applications such as aerostats or airships, said laminate comprising:
  - at least one woven fabric layer with an aggregate strength greater than 10 grams per denier;
  - 5 with the yarns in said fabric having sufficient twist to provide the high tensile conversion but less than the amount of twist that would produce unsatisfactory flex fatigue;
  - a yarn to fabric strength ratio sufficient to impart tear resistance to the fabric, but less than the ratio at which flex fatigue performance is unsatisfactory;
  - 10 said fabric having the minimal number of crossing points among the woven yarns that will impart sufficient integrity for the fabric to be manufactured into said laminate; and
  - a gas barrier material laminated to said fabric layer.
2. A laminate according to Claim 1 wherein the strength ratio of said fabric is between about 1:36 and 1:8.
3. An airship laminate according to Claim 1 wherein said yarns have a helix angle consistent with a twist of 6 turns per inch in a 1500 denier yarn.
4. An airship laminate according to Claim 1 wherein said yarns have a helix angle consistent with a twist of 4 turns per inch in a 1500 denier yarn.
5. An airship laminate according to Claim 1 wherein said yarns have a helix angle consistent with a twist of 2 turns per inch in a 1500 denier yarn.
6. An airship laminate according to Claim 1 wherein said gas barrier comprises:
  - a first layer of polyurethane on one face of said woven fabric layer; and
  - a second gas barrier layer on the opposite face of said woven fabric, said second gas barrier layer comprising,
    - 5 a layer of polyurethane on said fabric;

a layer of polyester film on said polyurethane layer;  
another layer of polyurethane on said polyester layer; and  
a layer of fluorocarbon polymer on said other polyurethane layer.

7. An airship laminate according to Claim 1 wherein said yarns in said woven fabric are selected from the group consisting of aromatic polyamide yarns, liquid crystal polyester yarns, and blends thereof.

8. A laminate for high strength, low weight gas enclosure applications such as aerostats or airships, said laminate comprising:

at least one woven fabric layer with an aggregate strength greater than 10 grams per denier; and

at least a first gas barrier layer laminated to one face of said fabric layer;  
said woven fabric layer comprising at least one sheet of yarns of high strength manufactured fibers.

9. An airship laminate according to Claim 8 wherein said woven fabric layer has an aggregate strength of at least 10 grams per denier.

10. An airship laminate according to Claim 8 and further comprising a second gas barrier layer laminated to the opposite face of said woven fabric from said first gas barrier layer.

11. An airship laminate according to Claim 10 wherein said first gas barrier layer comprises a single layer of polymeric material and said second gas barrier layer comprises a plurality of polymeric layers.

12. An airship laminate according to Claim 11 wherein said first gas barrier layer comprises polyurethane.

13. An airship laminate according to Claim 12 wherein said second gas barrier layer comprises:

a layer of polyurethane on said fabric;  
a layer of polyester film on said polyurethane layer;  
another layer of polyurethane on said polyester layer; and  
a layer of fluorocarbon polymer on said other polyurethane layer.

5

14. An airship laminate according to Claim 8 wherein said woven fabric comprises a basket weave.

15. An airship laminate according to Claim 8 wherein said woven fabric comprises a two by two basket weave.

16. An airship laminate according to Claim 8 wherein said woven fabric has less than 50% of available crossing points formed.

17. An airship laminate according to Claim 8 wherein said woven fabric having less than 20% of available crossing points formed.

18. An airship laminate according to Claim 8 comprising a plurality of fabric layers wherein each layer consists of at least one sheet of yarns.

19. An airship laminate according to Claim 18 wherein said fabric layers are different from one another.

20. An airship laminate according to Claim 8 wherein said yarns have a helix angle consistent with a twist of 6 turns per inch in a 1500 denier yarn.

21. An airship laminate according to Claim 8 wherein said yarns have a helix angle consistent with a twist of 4 turns per inch in a 1500 denier yarn.

22. An airship laminate according to Claim 8 wherein said yarns have a helix angle consistent with a twist of 2 turns per inch in a 1500 denier yarn.

23. An airship laminate according to Claim 8 wherein said yarns have a height-to-width aspect ratio of between 1:2 and 1:7.

24. An airship laminate according to Claim 8 wherein said woven fabric has a yarn to fabric strength ratio of between 1:36 and 1:8.

25. An airship laminate according to Claim 8 wherein said yarns in said woven fabric are selected from the group consisting of aromatic polyamide yarns, liquid crystal polyester yarns, and blends thereof.

26. An airship comprising:

a gas envelope; and

a tail assembly;

said gas envelope comprising,

at least one woven fabric layer with an aggregate strength greater than 10 grams per denier;

with the yarns in said fabric having sufficient twist to provide the desired tensile conversion but less than the amount of twist that would produce unsatisfactory flex fatigue;

10 a yarn to fabric strength ratio sufficient to impart tear resistance to the fabric, but less than the coarseness ratio at which flex fatigue performance is unsatisfactory;

said fabric having the minimal number of crossing points among the woven yarns that will impart sufficient integrity for the fabric to be manufactured into said laminate; and

15 a gas barrier material laminated to said fabric layer.

27. An airship according to Claim 26 wherein said gas envelope comprises a series of panels fixed together to form said envelope.

28. An airship according to Claim 26 and further comprising an internal framework made of a rigid lightweight material.

29. An airship according to Claim 26 wherein said lightweight material is selected from the group consisting of metals, polymers, composites formed of fibers and polymers, and combinations thereof.

30. An airship according to Claim 26 and further comprising a propulsion system.

31. An airship according to Claim 26 wherein said tail assembly comprises tilttable horizontal and vertical tail members.

32. An airship laminate according to Claim 26 wherein said yarns have a helix angle consistent with a twist of 6 turns per inch in a 1500 denier yarn.

33. An airship laminate according to Claim 26 wherein said yarns have a helix angle consistent with a twist of 4 turns per inch in a 1500 denier yarn.

34. An airship laminate according to Claim 26 wherein said yarns have a helix angle consistent with a twist of 2 turns per inch in a 1500 denier yarn.

35. An airship according to Claim 26 wherein said yarns have a height-to-width aspect ratio of between 1:2 and 1:7.

36. An airship according to Claim 26 wherein said woven fabric has a yarn to fabric strength ratio of between 1:36 and 1:8.

37. An airship according to Claim 26 wherein said first gas barrier layer comprises a single layer of polymeric material and said second gas barrier layer comprises a plurality of polymeric layers.

38. An airship according to Claim 37 wherein said first gas barrier layer comprises polyurethane.

39. An aerostat according to Claim 38 wherein said second gas barrier layer comprises:

a layer of polyurethane on said fabric;

a layer of polyester film on said polyurethane layer;

another layer of polyurethane on said polyester layer; and

a layer of fluorocarbon polymer on said other polyurethane layer.

40. An airship according to Claim 26 wherein said yarns in said woven fabric are selected from the group consisting of aromatic polyamide yarns, liquid crystal polyester yarns, and blends thereof.

41. A laminate for high strength, low weight gas enclosure applications such as aerostats or airships, said laminate comprising:

at least one woven fabric layer with an aggregate strength greater than 10 grams per denier; and

5 a first gas barrier layer;

said woven fabric consisting essentially of yarns that have a cross-sectional height-to-width aspect ratio of between about 1:2 and 1:7.

42. An airship laminate according to Claim 41 wherein said yarns have a helix angle consistent with a twist of 6 turns per inch in a 1500 denier yarn.

43. An airship laminate according to Claim 41 wherein said yarns have a helix angle consistent with a twist of 4 turns per inch in a 1500 denier yarn.

44. An airship laminate according to Claim 41 wherein said yarns have a helix angle consistent with a twist of 2 turns per inch in a 1500 denier yarn.

45. An airship laminate according to Claim 41 wherein said woven fabric has a yarn to fabric strength ratio of between 1:36 and 1:8.

46. An airship laminate according to Claim 41 and further comprising a second gas barrier layer laminated to the opposite face of said woven fabric from said first gas barrier layer.

47. An airship laminate according to Claim 46 wherein said first gas barrier layer comprises a single layer of polymeric material and said second gas barrier layer comprises a plurality of polymeric layers.

48. An airship laminate according to Claim 47 wherein said second gas barrier layer comprises:

- 5 a layer of polyurethane on said fabric;
- a layer of polyester film on said polyurethane layer;
- another layer of polyurethane on said polyester layer; and
- a layer of fluorocarbon polymer on said other polyurethane layer.

49. An airship laminate according to Claim 41 wherein said yarns in said woven fabric are selected from the group consisting of aromatic polyamide yarns, liquid crystal polyester yarns, and blends thereof.

50. A laminate for high strength, low weight gas enclosure applications such as aerostats or airships, said laminate comprising:

at least one woven fabric layer with an aggregate strength greater than 10 grams per denier; and

5 a first gas barrier layer;

said woven fabric being formed of yarns; and

said fabric having a yarn-to-fabric strength ratio of between about 1:36 and 1:8.

51. A laminate according to Claim 50 wherein said yarns have a helix angle consistent with a twist of 6 turns per inch in a 1500 denier yarn.

52. A laminate according to Claim 50 wherein said yarns have a helix angle consistent with a twist of 4 turns per inch in a 1500 denier yarn.

53. A laminate according to Claim 50 wherein said yarns have a helix angle consistent with a twist of 2 turns per inch in a 1500 denier yarn.

54. A laminate according to Claim 50 wherein said yarns have a height-to-width aspect ratio of between 1:2 and 1:7.

55. A laminate according to Claim 50 and further comprising a second gas barrier layer laminated to the opposite face of said woven fabric from said first gas barrier layer.

56. A laminate according to Claim 55 wherein said first gas barrier layer comprises a single layer of polymeric material and said second gas barrier layer comprises a plurality of polymeric layers.

57. A laminate according to Claim 56 wherein said second gas barrier layer comprises:

a layer of polyurethane on said fabric;

a layer of polyester film on said polyurethane layer;

5 another layer of polyurethane on said polyester layer; and

a layer of fluorocarbon polymer on said other polyurethane layer.

58. A laminate according to Claim 50 wherein said yarns in said woven fabric are selected from the group consisting of polyimide yarns, polyamide yarns, polyester yarns, and blends thereof.

59. A laminate for high strength, low weight gas enclosure applications such as aerostats or airships, said laminate comprising:

at least one woven fabric layer with an aggregate strength greater than 10 grams per denier; and

a first gas barrier layer;

said woven fabric being formed of twisted yarns; and

said yarns having no more than 6 twists per inch and a helix angle consistent with a 1500 denier yarn with between 2 and 6 turns per inch.

60. A laminate according to Claim 59 in which said yarns have a helix angle consistent with the helix angle of a 1500 denier yarn that has between 2 and 6 turns per inch.

61. A laminate according to Claim 59 wherein said yarns have a height-to-width aspect ratio of between 1:2 and 1:7.

62. A laminate according to Claim 59 wherein said woven fabric has a yarn to fabric strength ratio of between 1:36 and 1:8.

63. A laminate according to Claim 59 and further comprising a second gas barrier layer laminated to the opposite face of said woven fabric from said first gas barrier layer.

64. A laminate according to Claim 63 wherein said first gas barrier layer comprises a single layer of polymeric material and said second gas barrier layer comprises a plurality of polymeric layers.

65. A laminate according to Claim 64 wherein said second gas barrier layer comprises:

a layer of polyurethane on said fabric;

a layer of polyester film on said polyurethane layer;

another layer of polyurethane on said polyester layer; and

a layer of fluorocarbon polymer on said other polyurethane layer.

66. A laminate according to Claim 59 wherein said yarns in said woven fabric are selected from the group consisting of polyimide yarns, polyamide yarns, polyester yarns, and blends thereof.